

(19) World Intellectual Property Organization  
International Bureau



(43) International Publication Date  
18 January 2001 (18.01.2001)

PCT

(10) International Publication Number  
**WO 01/04003 A1**

(51) International Patent Classification<sup>7</sup>: B64C 7/00, 25/16

(21) International Application Number: PCT/GB00/02525

(22) International Filing Date: 29 June 2000 (29.06.2000)

(25) Filing Language: English

(26) Publication Language: English

(30) Priority Data:  
9915977.4 8 July 1999 (08.07.1999) GB

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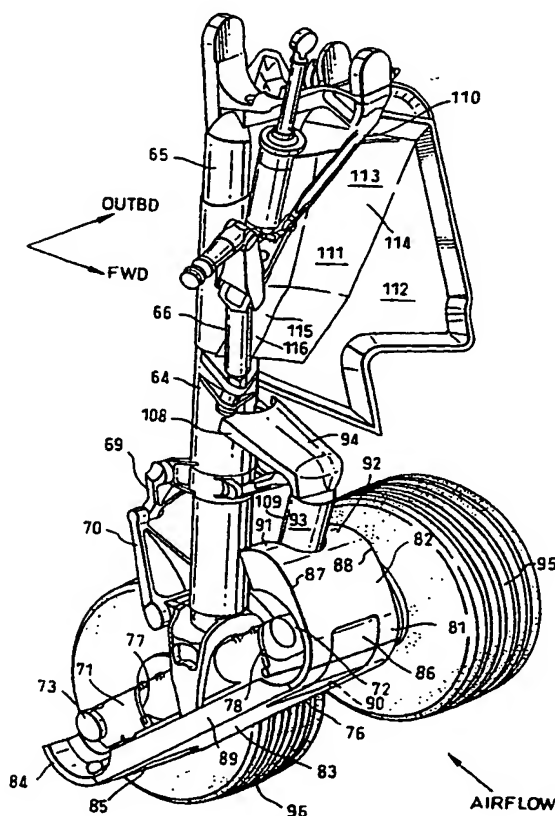
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(81) Designated States (national): AE, AG, AL, AM, AT, AU, AZ, BA, BB, BG, BR, BY, CA, CH, CN, CR, CU, CZ, DE, DK, DM, DZ, EE, ES, FI, GB, GD, GE, GH, GM, HR, HU, ID, IL, IN, IS, JP, KE, KG, KP, KR, KZ, LC, LK, LR, LS, LT, LU, LV, MA, MD, MG, MK, MN, MW, MX, MZ, NO.

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(54) Title: AIRCRAFT NOISE REDUCTION APPARATUS



(57) Abstract: An aircraft, aircraft landing gear and apparatus including at least one attachment (15, 17, 76, 93, 94, 111) for noise reduction purposes are provided. Such attachments are shaped and positioned on the landing gear to deflect air away from noise-inducing components (64, 65) of the landing gear and to permit deflection and articulation movement and also stowage of the landing gear whilst the attachments are installed thereon. The attachments are not designed to be drag-reducing.

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AIRCRAFT NOISE REDUCTION APPARATUS

This invention relates to aircraft noise reduction apparatus, in particular to apparatus to reduce noise emanating from landing gear of the aircraft when deployed on approach to landing.

The invention has particular application to commercial aircraft when landing at airports in or near to built up areas where aircraft approach noise is an increasing nuisance with increasing frequency of use of airports and ever larger aircraft. Noise emanating from commercial aircraft, whether cargo aircraft and/or passenger carrying aircraft, is now an important environmental issue. The increasing frequency of use of airports has led to aircraft of increasing size being used. This in turn has led to greater noise being generated by each aircraft in its approaches to the airport. Modern high bypass ratio turbofan engines are now extremely quiet on approach to landing and dominant noise on some aircraft types, perceived at ground level, is starting to become the noise generated by landing gear and by high lift devices on the wings.

This invention addresses the problem of aircraft noise, as perceived at ground level, generated by landing gear. Although noise is likely to be induced by any element which creates turbulence in the airflow past the landing gear, those elements which have been found particularly likely to create high noise levels are as follows:- elements which act as Helmholtz resonators such as hollow axles, apertures, fastener fittings, spindles, etc; also elements likely to create small vortices such as small protuberances, sharp edges; dressings such as small pipes, tubes, cables, and coil springs, etc. All such features are to be found aplenty on modern landing gear and tend to be more prevalent in the region of steering gear and wheel axles.

Although wind tunnel tests have been carried out on landing gear fully enclosed by fairings to determine noise levels in the far field, such full enclosure fairings are normally completely impractical for everyday use on an aircraft. This is because articulation of the landing gear during deployment and retraction movement is prevented by the fairings and because very limited stowage space in the landing gear bay in most aircraft will not accommodate full enclosures owing to

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In regions of the landing gear where incident air is accelerated between components of the landing gear, such as struts, stays and actuators, at least one said attachment is preferably positioned to deflect incident air away from the said air-accelerating region. In this way any noise-inducing components of the landing gear positioned in the said air-accelerating region will not be subject to the passage of such accelerated high speed air past them.

The apparatus may include an axle attachment positionable in front of an axle for nose gear of the aircraft to deflect air away from noise inducing components such as landing gear dressings in the region of the axle.

The axle attachment may be shaped to shield items such as a towbar fitting on the nose gear and the said shaped portion is desirably separately removable or pivotable out of the way in order to provide access to such a towbar fitting without disturbing the remainder of the axle attachment. Cam fasteners or other quick release fittings are suitable for fastening the shaped portion.

The axle attachment may extend laterally into close proximity with the wheels and may include generally cylindrical wheel extensions extending between a central portion thereof and each wheel whereby to deflect air away from noise inducing components on the axle and at the same time to deflect air away from a cavity formed within each wheel.

The wheel extensions preferably extend into close proximity with a rim of each wheel. Alternatively the wheels may be fitted with inner hub caps or wheel fillers. Such fillers may be of say foam material formed in two opposing sections with wedge-shaped elements driven into position therebetween. The foam or like material is preferably covered on the outside with a weatherproof material.

The axle attachment may include upper extension portions for positioning on either side of a main leg of the nose gear to deflect air away from torque link attachments usually sited on the axle.

The apparatus may include a said attachment positionable in front of a steering mechanism for the landing gear. Such a steering mechanism has been found to be prone to noise inducement including, as it usually does, many sharp edges, apertures and sundry pipe and cable work.

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Where the landing gear includes a wheeled bogie having a bogie beam the apparatus may include an attachment in the form of an undertray extending in front of and underneath the bogie beam to deflect air away from noise inducing elements in the region of the bogie beam, for example brake rods, bearings and their mountings, other fittings and sundry pipe and cable work.

An advantage of the undertray not extending above and behind the bogie beam is that inspection and maintenance access and air cooling are not thereby prevented by the attachment.

Where the bogie beam is tilted upwardly at the front, during approach, the area of the bogie beam left exposed is downstream of the undertray and thus the passage of high speed air past noise inducing components associated with the bogie beam is prevented by the undertray attachment.

Preferably the undertray includes at least one door therein to provide access to concealed items such as jacking points for the bogie.

The undertray may have a single curvature aerodynamic surface and may be of a width to permit air to pass between the undertray and wheels on the bogie to cool brakes. Preferably the undertray includes a forward upwardly extending aerodynamic surface blended smoothly into an under surface extending underneath and along the bogie beam, desirably with a further surface extending longitudinally of the bogie beam on either side of the undertray depending from lateral edges of the undertray, preferably orthogonal to the said aerodynamic surface. In this way air spilling over each lateral edge of the undertray in the region of wheel brakes will be able freely to flow past the brakes but will not be accelerated past the brakes by any funnelling effect of the surface contours of the undertray.

Where the bogie includes a pair of forward articulation links a said attachment may comprise a pair of articulating fairings, one mounted to each articulation link with an aerodynamically contoured interface being defined between the fairings. Preferably the said interface comprises a generally spherical element on one fairing co-operating with generally circular section tubing of the

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items of the gear such as struts, stays and axles. Some attachments will inevitably need to be removed for maintenance, at some stage, and here ease of removal and re-fitting is essential. All attachments are also preferably retro-fittable to existing designs of landing gear.

According to a second aspect of the invention there is provided aircraft landing gear including apparatus according to the first aspect of the invention.

According to a third aspect of the invention there is provided an aircraft incorporating landing gear fitted with noise-reduction apparatus according to the first aspect of the invention.

The invention will now be described by way of example with reference to the accompanying drawings of which:-

Figure 1 is an orthogonal view of nose landing gear fitted with apparatus according to the invention,

Figure 2 is an orthogonal cut away view of main landing gear when fitted with apparatus according to the invention,

Figure 3 is an orthogonal view of part of a nose landing gear fitted with an attachment according to the invention,

Figure 4 is a top plan view of a torque link with fairing attachment,

Figure 5 is a section along the line V - V of Figure 4,

Figure 6 is a section through a nose landing gear lower drag stay with fairing attachment,

Figure 7 is a side view of a landing gear articulation link with fairing,

Figure 8 is a side detail view of a front end of an undertray attachment according to the invention,

Figure 9 is a section taken along the line IX - IX of Figure 8, and

Figure 10 is an orthogonal view of an aircraft main landing gear with wheels removed to show landing gear dressings.

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an aperture 40 in the torque link 14. Edges 41, 42 defining the aperture 40 are therefore covered by the attachment 16, just as are edges 43, 44. It will be noted that streamwise extending surfaces 45, 46 are blended in with the attachment 16 such that air leaving the attachment at positions 43, 44 blends with free stream air passing over surfaces 45, 46.

The steering mechanism attachment 17 is a generally domed shape formed to minimise any stagnation areas centrally thereof. Edge region 47 is shaped and positioned to merge air leaving the attachment with free stream air, tangential thereto. The region of the landing gear behind the attachment 17 is prone to noise generation and this attachment is effective for reducing noise emanating from the landing gear.

Steering actuator covers 18, 19 have domed ends 48, 49 and smoothly curving portions 50, 51 covering actuator tubes (not shown) and sundry pipework (not shown).

Referring to Figures 1 and 6, the lower drag stay 7 has a fairing attachment 20 positioned in front thereof. The attachment 20 is not designed to fit closely with the drag stay 7 but is made deliberately wider to deflect air not only past edges 52, 53 but also away from coil springs 54, 55 of the drag stay release mechanism 12. It will be noted that edge regions 56, 57 of the attachment 20 are shaped to blend in air leaving the attachment with free stream air. The coil springs 54, 55 may be fitted with socks, preferably transparent for inspection purposes, to reduce induced noise.

Lastly, main fitting attachments 21, 22 cover apertures defined between the main leg 4, diagonal bracing member 58 and a pintle member 59. The main fitting attachments are relatively planar on their front surface to allow space for articulation of the nose gear during retraction and stowage.

It will be seen that the fitting of relatively brief fairing attachments to the nose gear has had the effect of covering many quite troublesome areas of noise generation but that these attachments may be easily removed for access and are in all cases designed to allow for compression of the main leg and articulating movement of the nose gear and stowage thereof in its stowage bay (not shown).

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its dressings 61 (see Figure 10). The undertray has a pair of openable access doors 85, 86 for access to jacking points (not shown). Depending from lateral edges 87, 88 of the undertray are a pair of laterally facing surfaces 89, 90 extending longitudinally of the bogie beam on either side of the undertray. The forwardly upwardly extending portion 82 has extensions 91, 92 wrapping around a lower articulation link fairing attachment 93 which works in conjunction with an upper articulation link fairing attachment 94. With the landing gear in the approach position as shown in Figure 2 it can be seen that the forward portion 82 of the undertray wraps neatly around the lower articulation link fairing attachment 93 to provide a smooth aerodynamic contour of low noise configuration. It will be appreciated that the forward portion 82 of the undertray effectively deflects incident air away from the dressings 60.

The undertray is of a width to permit air to pass between wheels 95, 96 and the undertray for brake cooling. The form of the edges 87, 88 and longitudinally extending surfaces 89, 90 permits air to pass over brake callipers (not shown) between the undertray and the wheels but does not funnel air through these regions at increased speed and therefore create unnecessary noise. The shape of the undertray is generally adapted to deflect air away from noise inducing components on the bogie beam and landing gear generally whilst affording maximum access to the upper and side parts of the bogie beam for inspection and maintenance purposes. Weight saving is also achieved by this configuration, relative to a full enclosure.

The clamps 79, 80 for clamping the undertray to the axles 72, 73 comprise bands 97, 98 passing through part annular elements 99, 100 attached to the undertray (see Figures 8 and 9). This method of fitting is extremely rigid, robust and of relatively light weight.

The articulation link fairing 93, 94 is shown in Figure 2 and also in more detail in Figure 7. It will be appreciated that the articulation links 67, 68 (see Figure 10) work in conjunction with telescopic compression of the main leg 64. For this reason the fairing attachments 93, 94 must be able to pivot with respect to each other. Each is separately clamped to its articulation link by clamps 101, 102,

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CLAIMS

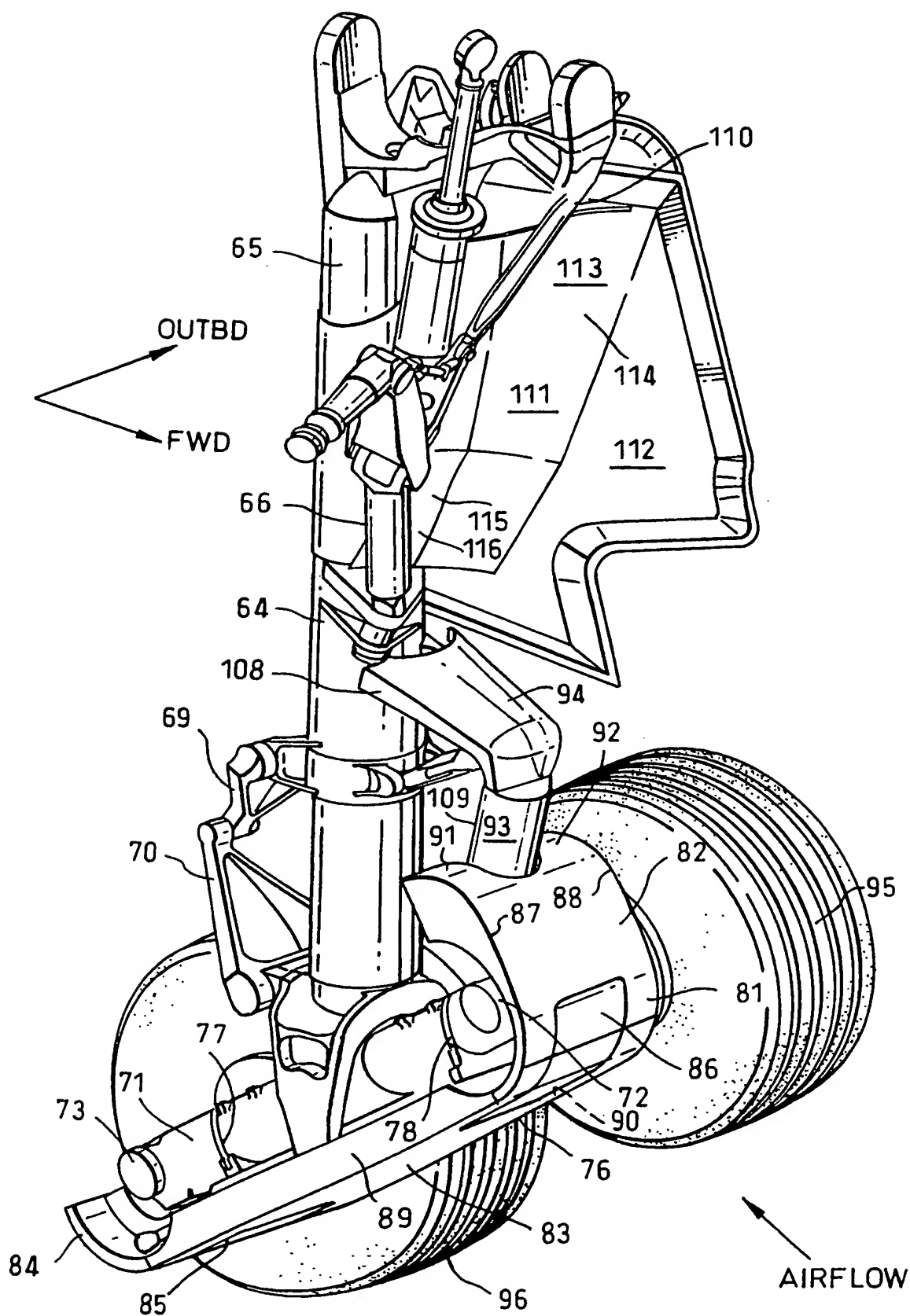
1. Aircraft noise reduction apparatus including at least one noise-reducing attachment (15,17,76,93,94,111) for landing gear of the aircraft shaped for positioning on the landing gear to deflect air away from noise inducing components of the landing gear and to permit deflection, articulation movement and stowage of the landing gear with the attachment installed.
2. Apparatus as in claim 1 in which a said attachment comprises a deflector screen (15,17,76,93,94,111) adapted not to completely surround noise inducing components on the landing gear.
3. Apparatus as in claim 1 or 2 in which the attachment comprises an axle attachment (15) positionable in front of an axle (3) for nose gear of the aircraft.
4. Apparatus as in claim 3 in which the axle attachment is shaped to enclose a towbar fitting (24).
5. Apparatus as in claim 3 or 4 in which the axle attachment includes generally cylindrical wheel extensions (30,31) extending between a central portion (32) thereof and each wheel (33).
6. Apparatus as in claim 1 or 2 in which the attachment comprises a steering mechanism attachment (17) for positioning in front of a steering mechanism for the landing gear.
7. Apparatus as in claim 1 or 2 including an apertured strut attachment (16) positionable over a said aperture (40) in the strut (14) to deflect air away from edges (41,42) of the aperture.
8. Apparatus as in claim 7 in which the attachment (16) is shaped to blend in airflow leaving the attachment with airflow passing over streamwise extending surfaces (45,46) of the strut, when in use.
9. Apparatus as in claim 7 or 8 in which the attachment (16) is shaped to deflect air away from noise-inducing elements on the landing gear positioned to the rear of the said strut (14).
10. Apparatus as in any preceding claim in which the attachment (15,17,76,93,94,111) is shaped to avoid regions of air stagnation thereover, when in use.



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17. Apparatus as in claim 16 in which the door attachment (111) is adapted for sealing engagement with the door (112).
18. Aircraft landing gear including apparatus according to any preceding claim.
19. Aircraft landing gear as in claim 18 in which at least one said attachment is shaped and positioned such that airflow over the attachment (16) during flight leaves the attachment substantially in the free stream direction.
20. Aircraft landing gear as in claim 18 or 19 in which at least one said attachment (111) is positioned to deflect incident air away from an air accelerating region formed between two components (64,65) of the landing gear.
21. Aircraft including landing gear according to any of claims 18 to 20.

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Fig.2.



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Fig.4.

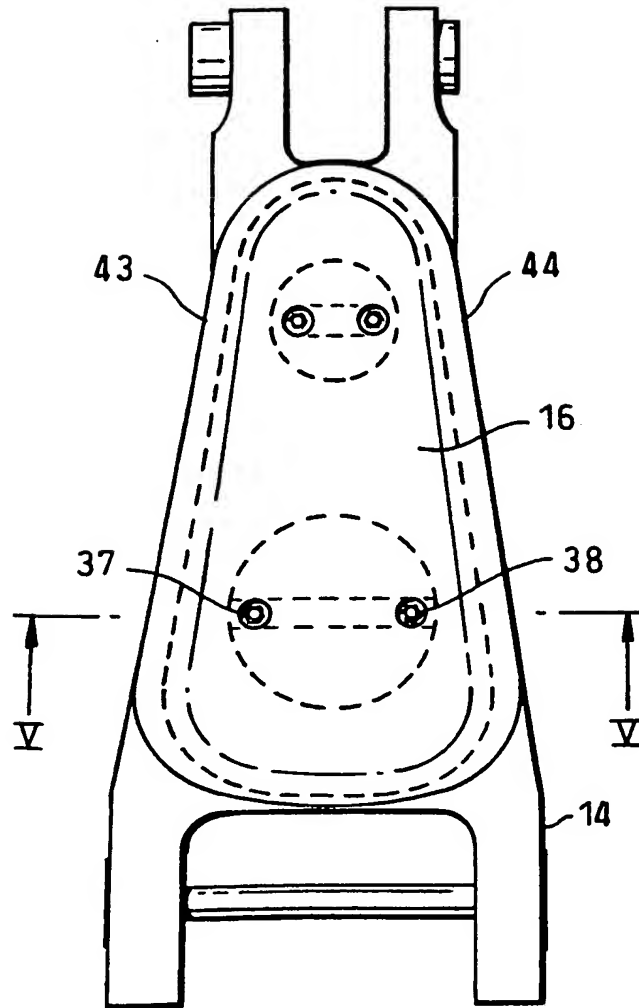
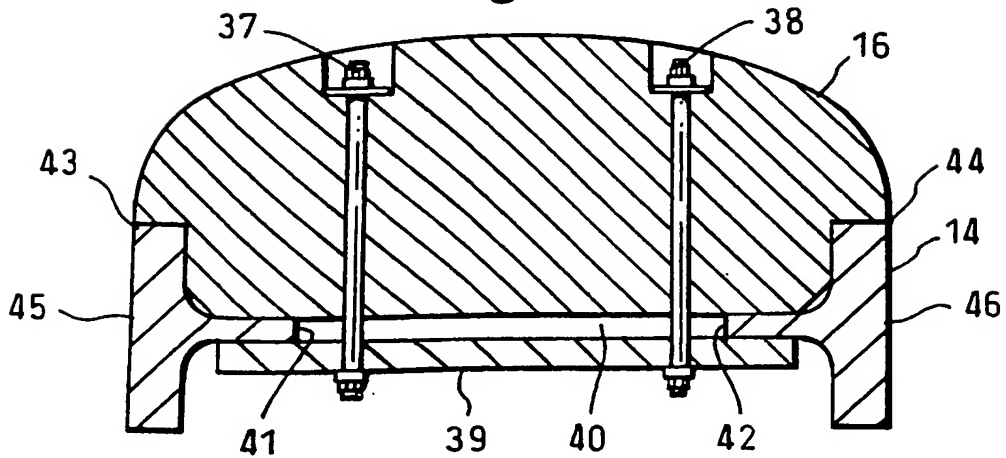


Fig.5.



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Fig.8.

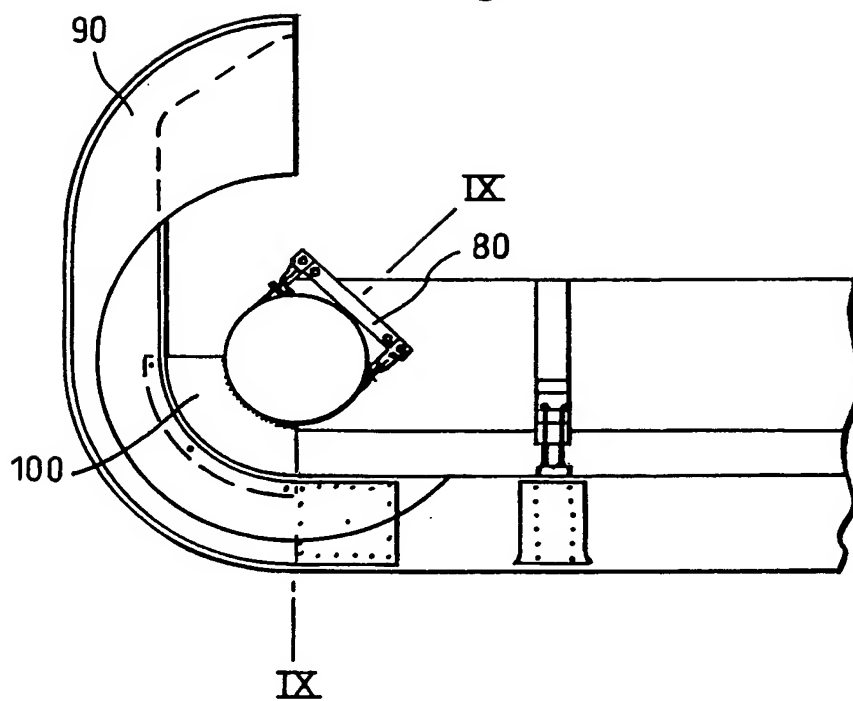
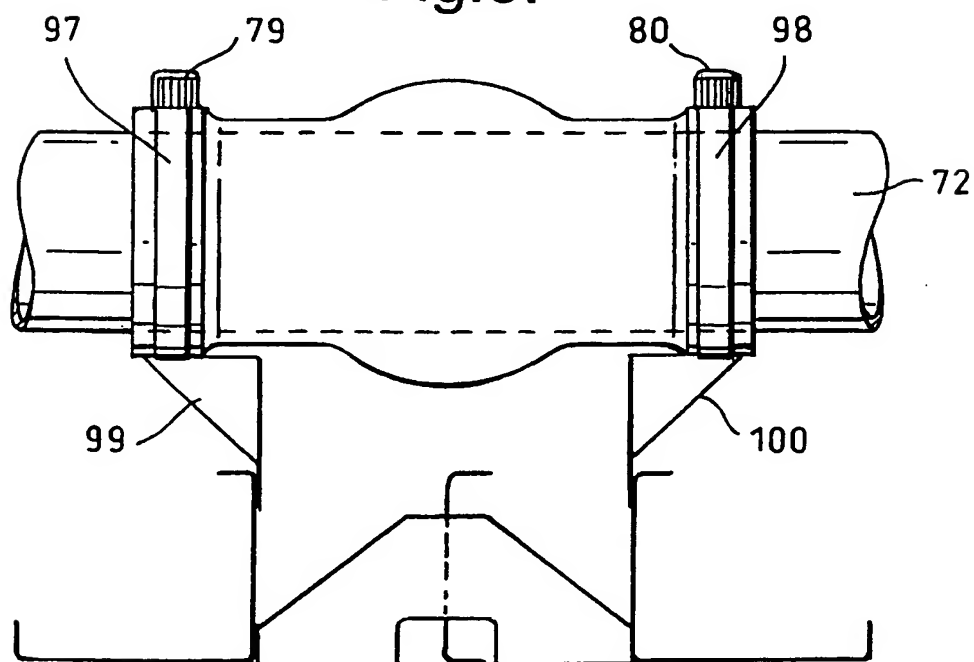


Fig.9.



# INTERNATIONAL SEARCH REPORT

International Application No

PCT/GB 00/02525

**A. CLASSIFICATION OF SUBJECT MATTER**  
IPC 7 B64C7/00 B64C25/16

According to International Patent Classification (IPC) or to both national classification and IPC

**B. FIELDS SEARCHED**

Minimum documentation searched (classification system followed by classification symbols)

IPC 7 B64C

Documentation searched other than minimum documentation to the extent that such documents are included in the fields searched

Electronic data base consulted during the international search (name of data base and, where practical, search terms used)

EPO-Internal

**C. DOCUMENTS CONSIDERED TO BE RELEVANT**

Category *	Citation of document, with indication, where appropriate, of the relevant passages	Relevant to claim No.
X	EP 0 846 540 A (BRITISH AEROSPACE) 10 June 1998 (1998-06-10) column 1, line 3 - line 23 column 4, line 11 - line 18 figure 1 ---	1-3, 5, 18-21
X A	US 2 180 462 A (A.P. DE SEVERSKY) 21 November 1939 (1939-11-21) page 2, right-hand column, line 43 -page 3, left-hand column, line 11 figures ---	1, 2, 10, 18-21 14, 16
X	GB 494 542 A (WALTER BLUME) page 1, line 54 - line 61 figures ---	1, 6
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☒ Further documents are listed in the continuation of box C.

☒ Patent family members are listed in annex.

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Date of the actual completion of the international search

20 September 2000

Date of mailing of the international search report

28/09/2000

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# INTERNATIONAL SEARCH REPORT

Information on patent family members

Int. l. Application No

PCT/GB 00/02525

Patent document cited in search report		Publication date	Patent family member(s)	Publication date
EP 0846540	A	10-06-1973	GB 2319981 A	10-06-1998
			CA 2223543 A	06-06-1998
			US 6048477 A	11-04-2000
US 2180462	A	21-11-1939	NONE	
GB 494542	A		NONE	
US 2129824	A	13-09-1938	NONE	